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(54) Abstract Title
Radio frequency (RF) detection circuit

(57) A radio frequency detection circuit includes a modulator (5) receiving first and second signals, a directional coupler (24), a distributor (23), a first diode (21), a second diode (22), an adder (18) adding the outputs of the first and second diodes (21,22) to each other, and transmitting a sum signal, and a comparison circuit (17) comparing the sum signal to a control signal and transmitting a feed-back signal to the modulator (5). The radio frequency detection circuit provides a wider range of detection characteristic. The two diodes (21,22) have different ranges of power which the diodes can detect.

FIG. 2

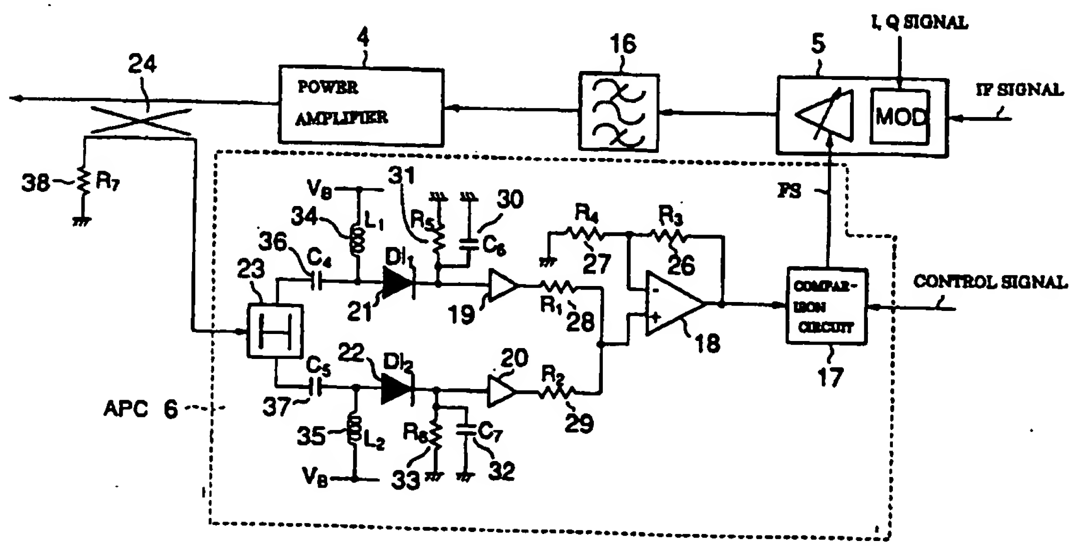

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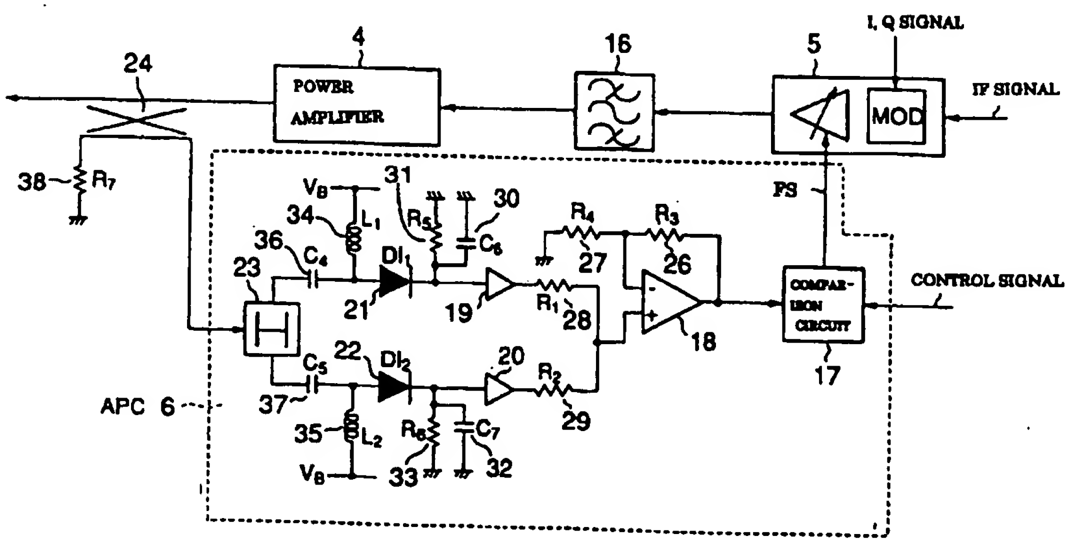
FIG. 2



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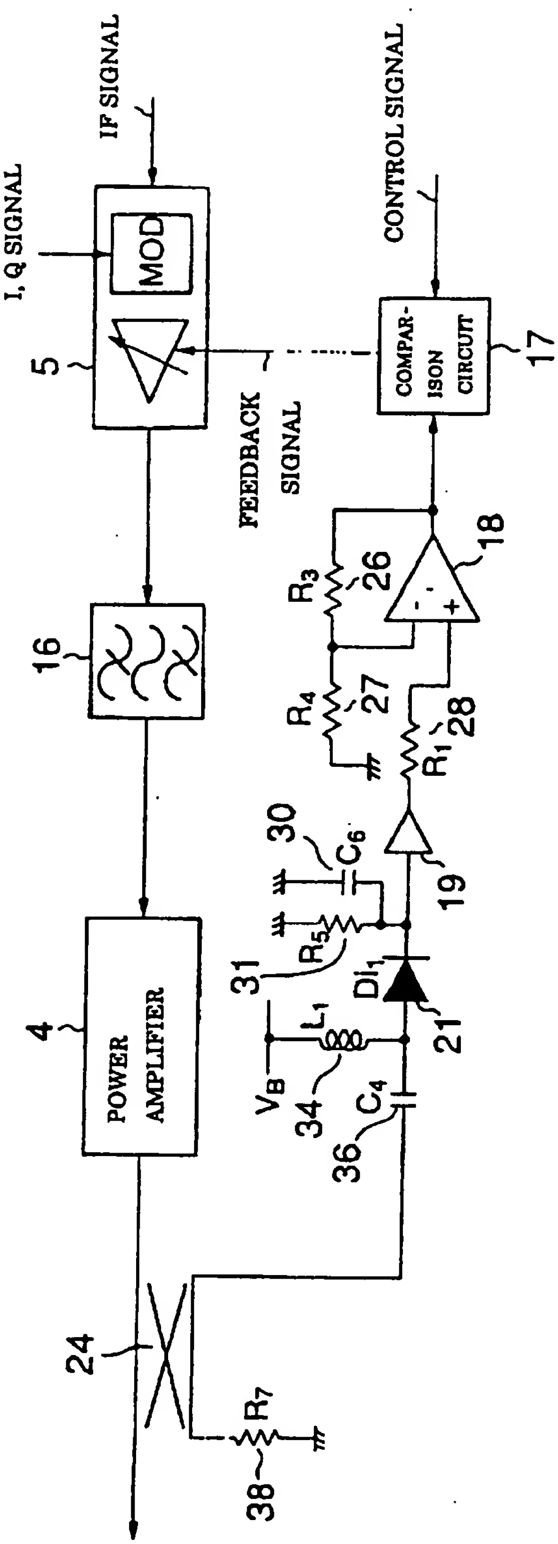


FIG. 1
PRIOR ART

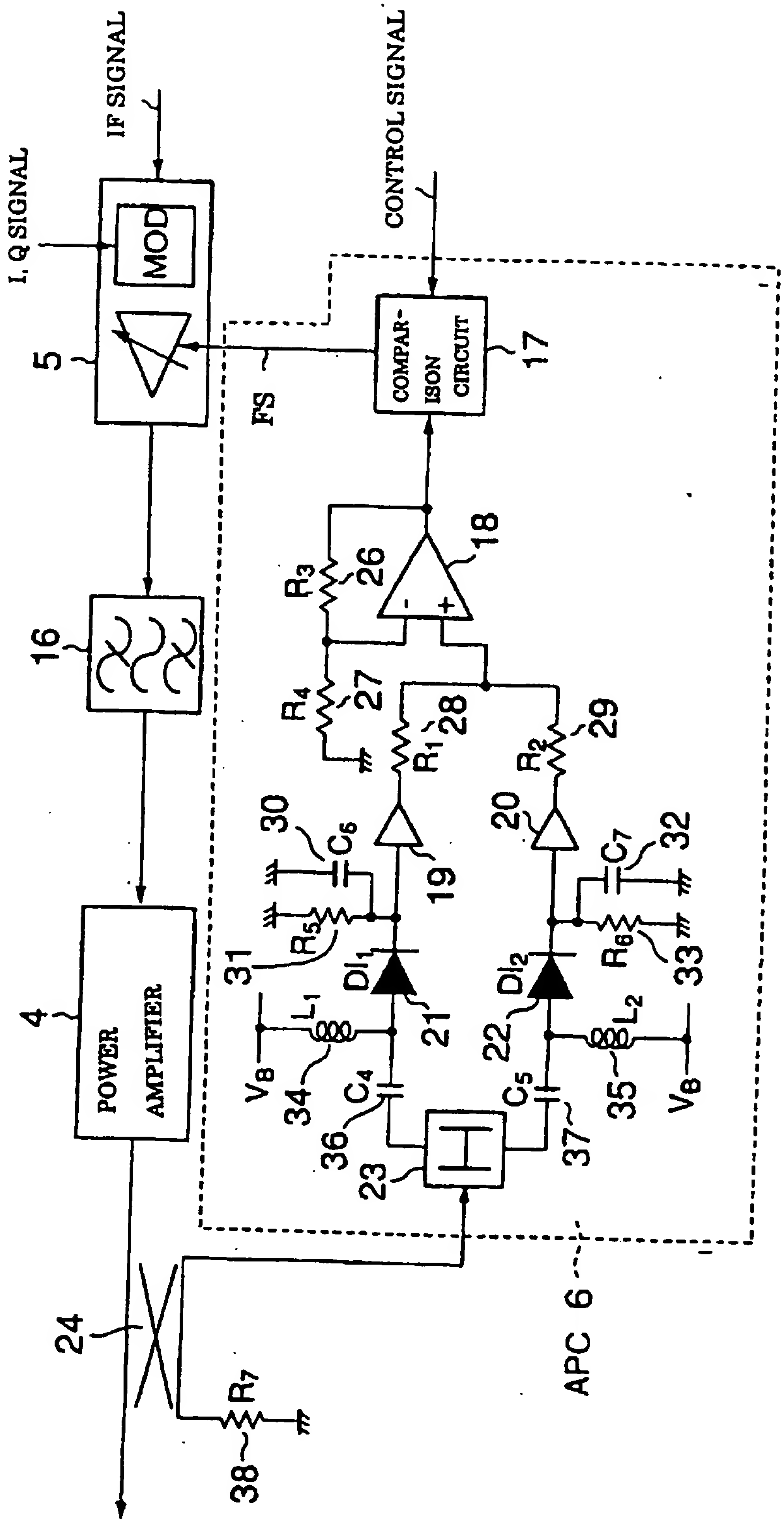
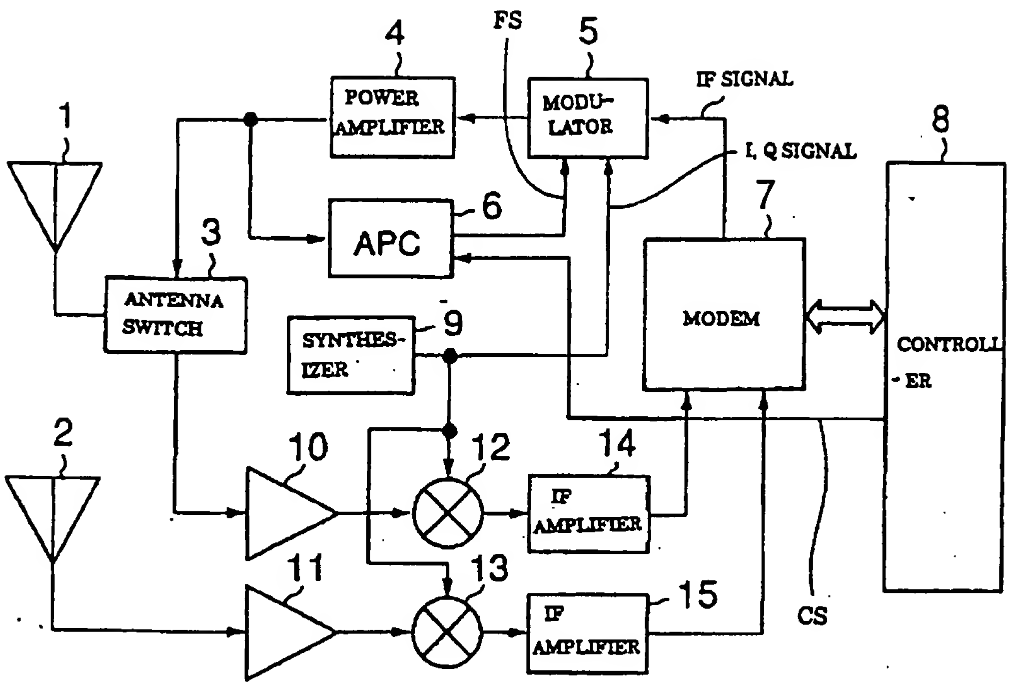

IF SIGNAL
I, Q SIGNAL
MOD
5
CONTROL SIGNAL
COMPAR-
ISON
CIRCUIT
17
FS
16
18
R3
26
R4
27
R1
28
R2
29
30
C6
19
20
C7
32
31
R5
DI1
21
DI2
22
R6
33
4
POWER
AMPLIFIER
VB
L1
34
C4
36
23
C5
37
35
L2
VB
24
R7
38
APC 6

FIG. 2

FIG. 3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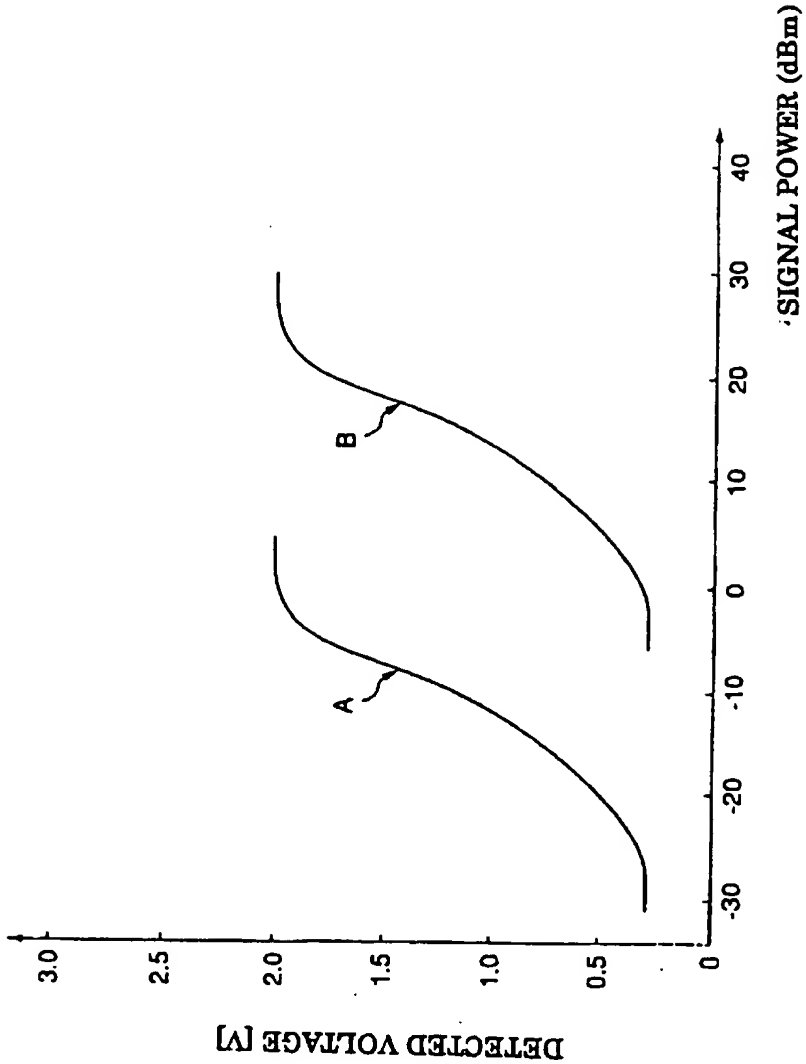
FS
5
POWER AMPLIFIER
MODU-LATOR
IF SIGNAL
1
I, Q SIGNAL
8
6
APC
7
3
ANTENNA SWITCH
MODEM
SYNTHES-IZER
9
CONTROLL-ER
2
10
12
14
IF AMPLIFIER
11
13
15
IF AMPLIFIER
CS

FIG. 4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3.0
2.5
2.0
1.5
1.0
0.5
0
-30
-20
-10
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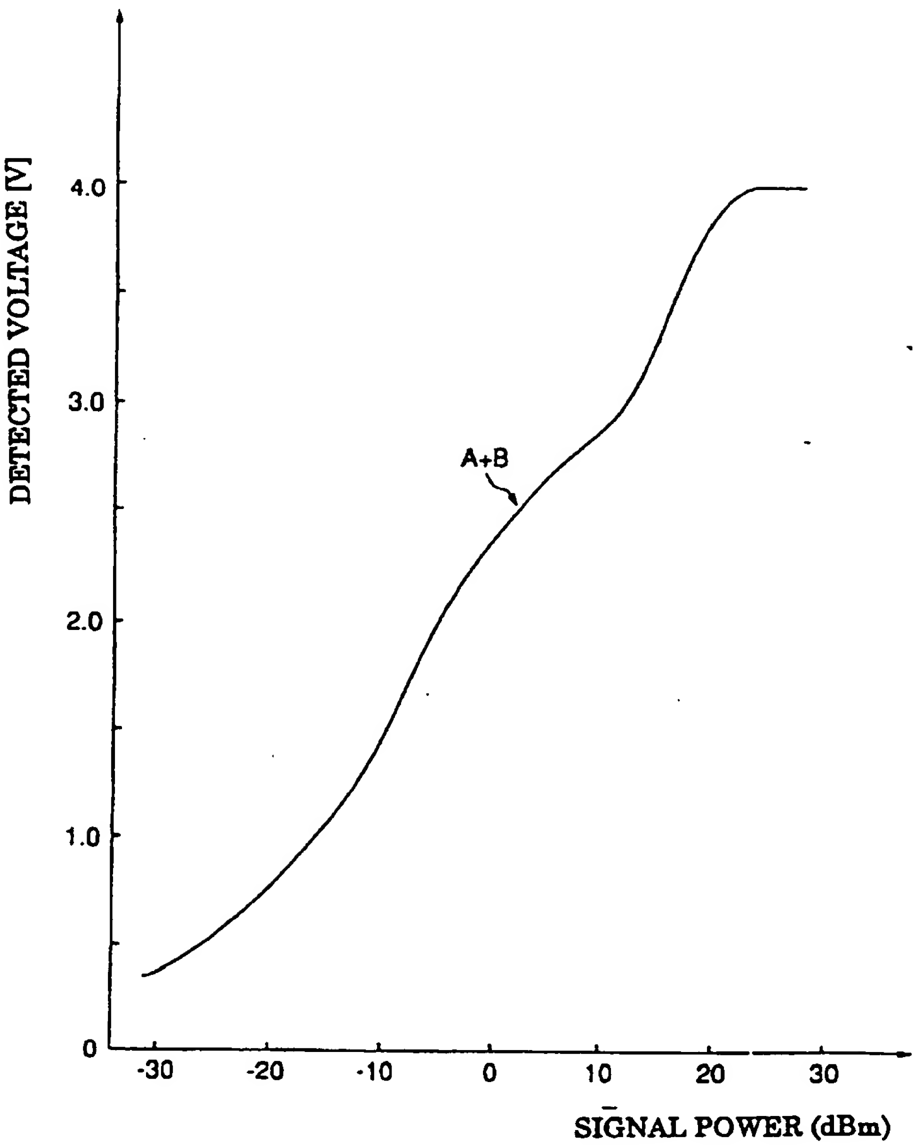
10
20
30
40
SIGNAL POWER (dBm)
A
B

FIG. 5


DETECTED VOLTAGE [V]
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3.0
2.0
1.0
0
A+B
-30
-20
-10
0
10
20
30
SIGNAL POWER (dBm)

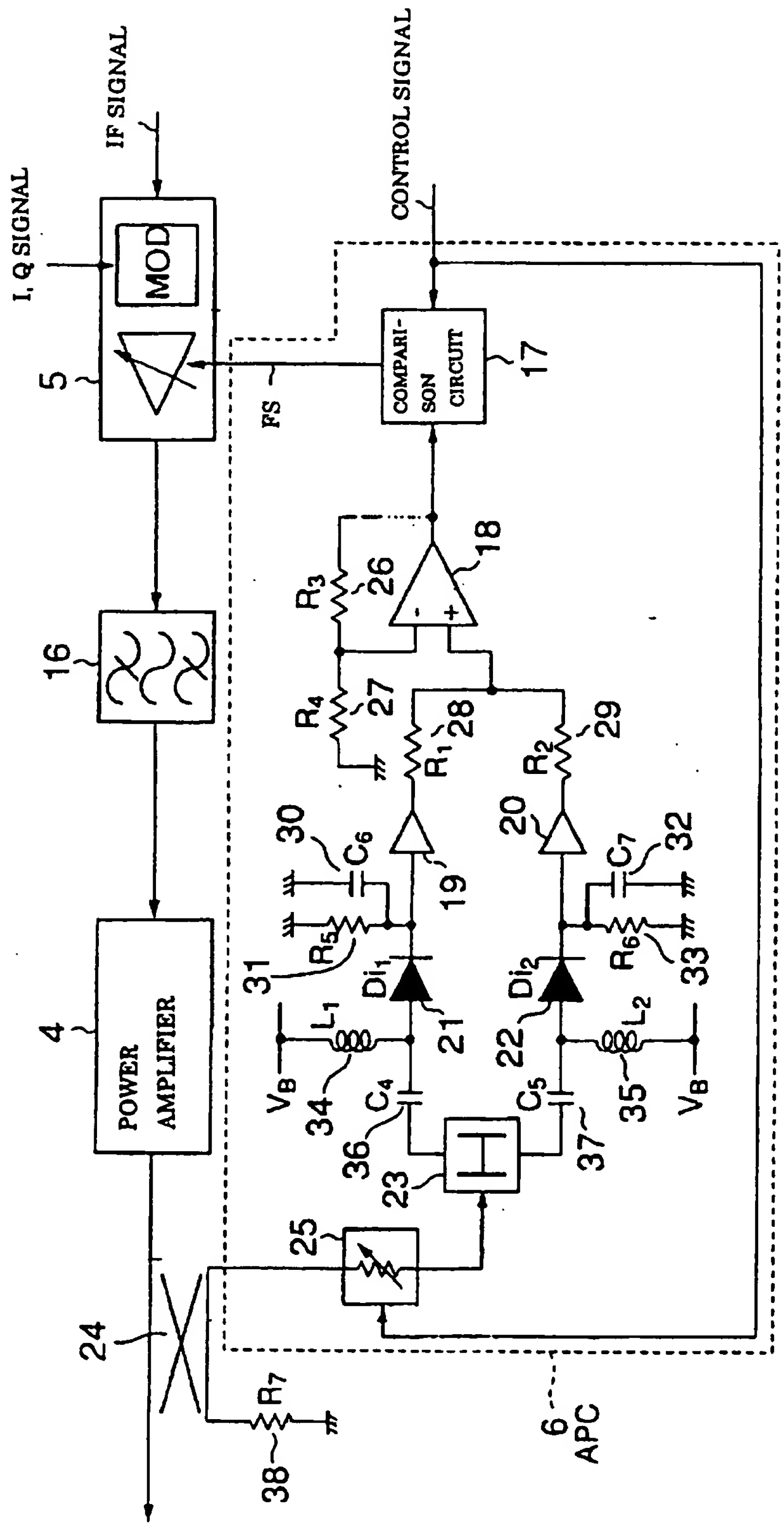
IF SIGNAL
I, Q SIGNAL
MOD
5
CONTROL SIGNAL
COMPARI-
SON
CIRCUIT
17
FS
16
18
R_3
26
R_4
27
R_1
28
R_2
29
POWER
AMPLIFIER
4
30
C_6
19
20
C_7
32
31
R_5
Di_1
21
Di_2
22
R_6
33
V_B
L_1
34
L_2
35
V_B
C_4
36
C_5
37
23
25
24
R_7
38
6
APC

FIG. 6

RADIO FREQUENCY (RF) DETECTION CIRCUIT

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The invention relates to a radio frequency detection circuit, and more particularly to a circuit used for detecting a transmitted signal in an auto power control (APC) circuit in a mobile communicator such as a cellular phone.

DESCRIPTION OF THE RELATED ART

Fig. 1 is a circuit diagram of a known RF detection circuit.

As illustrated in Fig. 1, the known RF detection circuit is comprised of a quadrature modulator 5 receiving IF signal and IQ signal, modulating those signals, and transmitting a single output signal, an interstage filter 16 receiving the output signal from the quadrature modulator 5, filtering the output signal, and transmitting the filtered signal, a power amplifier 4 receiving the filtered signal from the interstage filter 16, amplifying the signal and transmitting an output signal, a directional coupler 24 receiving the output signal from the power amplifier 4 and branching the received output signal into two first signals, a detection diode 21 receiving one of the first signals from the directional coupler 24, detecting the received first signal, and transmitting an output signal, a buffer amplifier 19 receiving the output signal from the detection diode 21, amplifying the received output signal, and transmitting a signal, an adding amplifier 18 receiving the signal at a positive terminal from the buffer amplifier 19, and grounded at a negative terminal through a third resistor 27, and a comparison circuit 17 receiving both an output signal transmitted from the adding amplifier 18 and a control signal transmitted from a controller (not illustrated), comparing those signals to each other, and transmitting a signal indicative of comparison, to the quadrature modulator 5, as a feed-back signal.

A first resistor 38 is electrically connected at one end to the directional

coupler 24 and grounded at the other end.

A first capacitor 36 is electrically connected in series between the directional coupler 24 and the detection diode 21.

A choke coil 34 is electrically connected at one end to a node between the first capacitor 36 and the detection diode 21, and electrically connected at the other end to a voltage source V_B.

A second resistor 31 is electrically connected to a node between the detection diode 21 and the buffer amplifier 19, and grounded at the other end.

A second capacitor 30 is electrically connected at one end in parallel with the second resistor 31, and grounded at the other end.

A fourth resistor 28 is electrically connected in series between the buffer amplifier 19 and the positive terminal of the adding amplifier 18.

A fifth resistor 26 is electrically connected between the negative terminal and an output port of the adding amplifier 18.

As is readily understood, the conventional RF detection circuit detects a signal by means of the single detection diode 21.

As a result, the known RF detection circuit could provide linearity characteristic only in the range of detection characteristic of the detection diode 21. That is, the conventional RF detection circuit could control signal power only in a dynamic range of about 25 dB or smaller.

However, a future device such as W-CDMA (Wideband-CDMA) will be required to carry out signal power control in a wider range, for instance, in a range of 50 dB or greater. Thus, the dynamic range in the known RF detection circuit is completely insufficient. Accordingly, it is necessary to widen dynamic range of detection characteristic in a RF detection circuit.

For instance, Japanese Unexamined Patent Publication No. 4-40105 has suggested a linearity amplifying circuit.

Japanese Patent Publication No. 7-71054 has suggested a circuit for controlling signal transmission output.

Japanese Unexamined Patent Publication No. 5-22061 has suggested an output power detection circuit.

Japanese Unexamined Patent Publication No. 7-297645 has suggested a detection circuit.

However, the circuits suggested in the above-mentioned Publications are all designed to include a single detection diode. Accordingly, these circuits are also accompanied with the problem that dynamic range in which signal power control is carried out is small for a future device.

SUMMARY OF THE INVENTION

In view of the above-mentioned problem, it is an object of the preferred embodiments of the present invention to provide a RF detection circuit which is capable of carrying out signal power control in a wider dynamic range than that of the conventional RF detection circuit.

The present invention is defined as independent claims 1, 6, 12, 18, 22, 26, 30, 31 and 32.

In one aspect of the present invention, there is provided a radio frequency detection circuit including at least two diodes electrically connected in parallel with one another, the diodes having different ranges of a voltage which the diodes can detect.

It is preferable that the radio frequency detection circuit further includes an attenuator through which a signal is transmitted to the diodes, the attenuator being turned on or off in accordance with a control signal.

For instance, the attenuator is turned on when a transmitted signal has a level equal to or greater than a first threshold level, and is turned off when a transmitted signal has a level equal to or smaller than a second threshold level.

It is preferable that the attenuator is a variable one.

For instance, the radio frequency detection circuit includes two diodes.

There is further provided a radio frequency detection circuit including (a) a modulator receiving first and second signals, and transmitting an output signal, (b) a directional coupler receiving the output signal from the modulator,

and dividing the thus received output signal into two first signals, (c) a distributor receiving one of the two first signals from the directional coupler, and dividing the thus received first signal into two second signals, (d) a first diode receiving one of the two second signals from the distributor, and transmitting a first output signal, (e) a second diode receiving the other of the two second signals from the distributor, and transmitting a second output signal, (f) an adder adding the first and second output signals to each other, and transmitting a sum signal, and (g) a comparison circuit receiving the sum signal and a control signal, comparing the sum signal to the control signal, and transmitting a feed-back signal indicative of comparison, to the modulator.

It is preferable that the radio frequency detection circuit further includes a attenuator electrically connected in series between the directional coupler and the distributor, the attenuator receiving the control signal in accordance with which the attenuator is turned on or off.

For instance, the attenuator is turned on when the control signal has a level equal to or greater than a first threshold level, and is turned off when the control signal has a level equal to or smaller than a second threshold level.

It is preferable that the attenuator is a variable attenuator.

It is preferable that the radio frequency detection circuit further includes (h) a first buffer amplifier electrically connected in series between the first diode and the adder, and (i) a second buffer amplifier electrically connected in series between the second diode and the adder.

It is preferable that the radio frequency detection circuit further includes (j) a first capacitor electrically connected in series between the distributor and the first diode, and (k) a second capacitor electrically connected in series between the distributor and the second diode.

In a further aspect of the invention, there is provided a radio frequency detection circuit including (a) a modulator receiving first and second signals, and transmitting an output signal, (b) a directional coupler receiving the output signal from the

modulator, and dividing the thus received output signal into two first signals, (c) a distributor receiving one of the two first signals from the directional coupler, and dividing the thus received first signal into N second signals wherein N is an integer equal to or greater than 3, (d) first to N-th diodes each receiving one of the N second signals from the distributor, and transmitting a first to N-th output signal, (e) an adder adding the first to N-th output signals to one another, and transmitting a sum signal, and (g) a comparison circuit receiving the sum signal and a control signal, comparing the sum signal to the control signal, and transmitting a feed-back signal indicative of comparison, to the modulator.

It is preferable that the radio frequency detection circuit further includes first to N-th buffer amplifiers each electrically connected in series between the first to N-th diodes and the adder

It is preferable that the radio frequency detection circuit further includes first to N-th capacitors each electrically connected in series between the distributor and the first to N-th diodes.

In another aspect of the present invention, there is provided a method of detecting radio frequency, including the steps of (a) modulating first and second signals, and transmitting an output signal, (b) dividing the output signal into two first signals, (c) detecting the two first signals, and resultingly transmitting two second signals, (d) adding the two second signals to each other, and transmitting a sum signal, and (e) comparing the sum signal to a control signal, and transmitting a feed-back signal indicative of comparison, the feed-back signal being fed back to the step (a).

It is preferable that the method further includes the step of (f) attenuating the output signal, the step (f) being to be carried out after the step (a), but prior to the step (b).

In another aspect of the invention, there is provided a method of detecting radio frequency, including the steps of (a) modulating first and second signals, and transmitting an output signal, (b) dividing the output signal into N first signals wherein N is an

integer equal to or greater than 3, (c) detecting the N first signals, and resultingly transmitting N second signals, (d) adding the N second signals to one another, and transmitting a sum signal, and (e) comparing the sum signal to a control signal, and transmitting a feed-back signal indicative of comparison, the feed-back signal being fed back to the step (a).

In still another aspect of the present invention, there is provided a radio frequency circuit to be used in a mobile transceiver, including (a) a controller transmitting a control signal, (b) a modem transmitting first and second signals, (c) a modulator receiving the first and second signals, and transmitting an output signal, (d) a directional coupler receiving the output signal from the modulator, and dividing the thus received output signal into two first signals, (e) a distributor receiving one of the two first signals from the directional coupler, and dividing the thus received first signal into two second signals, (f) a first diode receiving one of the two second signals from the distributor, and transmitting a first output signal, (g) a second diode receiving the other of the two second signals from the distributor, and transmitting a second output signal, (h) an adder adding the first and second output signals to each other, and transmitting a sum signal, and (i) a comparison circuit receiving the sum signal and the control signal, comparing the sum signal to the control signal, and transmitting a feed-back signal indicative of comparison, to the modulator.

It is preferable that the radio frequency circuit further includes a attenuator electrically connected in series between the directional coupler and the distributor, the attenuator receiving the control signal in accordance with which the attenuator is turned on or off.

It is preferable that the attenuator is turned on when the control signal has a level equal to or greater than a first threshold level, and is turned off when the control signal has a level equal to or smaller than a second threshold level.

It is preferable that the attenuator is a variable one.

There is further provided a radio frequency circuit to be used in a

mobile transceiver, including (a) a controller transmitting a control signal, (b) a modem transmitting first and second signals, (c) a modulator receiving the first and second signals, and transmitting an output signal, (d) a directional coupler receiving the output signal from the modulator, and dividing the thus received output signal into two first signals, (e) a distributor receiving one of the two first signals from the directional coupler, and dividing the thus received first signal into N second signals wherein N is an integer equal to or greater than 3, (f) first to N-th diodes each receiving one of the N second signals from the distributor, and transmitting a first to N-th output signal, (g) an adder adding the first to N-th output signals to one another, and transmitting a sum signal, and (h) a comparison circuit receiving the sum signal and the control signal, comparing the sum signal to the control signal, and transmitting a feed-back signal indicative of comparison, to the modulator.

The advantages obtained by the aforementioned present invention will be described hereinbelow.

In accordance with the present invention, a RF detection circuit could have a higher dynamic range for signal power control than that of the conventional RF detection circuit.

In accordance with the present invention, two or more detection diodes having different ranges of a voltage which the diodes can detect are operated in parallel, and outputs of those diodes are added to one another. As a result, it is possible to improve linearity in detection of a voltage, and accordingly, widen dynamic range in signal power control.

In addition, it would be possible to further widen dynamic range for signal power control, by locating a variable attenuator upstream of the detection diodes and turning the variable attenuator on or off in accordance with a control signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a circuit diagram of a conventional RF detection circuit.

Fig. 2 is a circuit diagram of a RF detection circuit in accordance with the first embodiment of the present invention.

Fig. 3 is a block diagram of a mobile communicator including the RF detection circuit in accordance with the first embodiment.

Fig. 4 is a graph showing detection characteristics of the two detection diodes employed in the RF detection circuit in accordance with the first embodiment.

Fig. 5 is a graph showing combined detection characteristic of the two detection diodes employed in the RF detection circuit in accordance with the first embodiment.

Fig. 6 is a circuit diagram of a RF detection circuit in accordance with the second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[First Embodiment]

Fig. 2 is a circuit diagram of a RF detection circuit in accordance with the first embodiment.

As illustrated in Fig. 2, the RF detection circuit is comprised of a quadrature modulator 5 receiving IF signal and IQ signal, modulating those signals, and transmitting a single output signal, an interstage filter 16 receiving the output signal from the quadrature modulator 5, filtering the output signal, and transmitting the filtered signal, a power amplifier 4 receiving the filtered signal from the interstage filter 16, amplifying the signal and transmitting an output signal, a directional coupler 24 receiving the output signal from the power amplifier 4 and branching the received output signal into two first signals, a distributor 23 receiving one of the first signals from the directional coupler 24, and dividing the received first signal into two second signals, a first detection

diode 21 receiving one of the second signals from the distributor 23, detecting the received second signal, and transmitting a first output signal, a first buffer amplifier 19 receiving the first output signal from the first detection diode 21, amplifying the received first output signal, and transmitting a signal, a second detection diode 22 receiving one of the second signals from the distributor 23, detecting the received second signal, and transmitting a second output signal, a second buffer amplifier 20 receiving the second output signal from the second detection diode 22, amplifying the received second output signal, and transmitting a signal, an adding amplifier 18 receiving the signals at a positive terminal from the first and second buffer amplifiers 19 and 20, and grounded at a negative terminal, and a comparison circuit 17 receiving both an output signal transmitted from the adding amplifier 18 and a control signal transmitted from a controller (not illustrated), comparing those signals to each other, and transmitting a signal indicative of comparison, to the quadrature modulator 5, as a feed-back signal.

A first resistor 38 is electrically connected at one end to the directional coupler 24 and grounded at the other end.

A first capacitor 36 is electrically connected in series between the directional coupler 24 and the first detection diode 21. A second capacitor 37 is electrically connected in series between the directional coupler 24 and the second detection diode 22.

A first choke coil 34 is electrically connected at one end to a node between the first capacitor 36 and the first detection diode 21, and electrically connected at the other end to a voltage source V_B. A second choke coil 35 is electrically connected at one end to a node between the second capacitor 37 and the second detection diode 22, and electrically connected at the other end to a voltage source V_B.

A second resistor 31 is electrically connected to a node between the first detection diode 21 and the first buffer amplifier 19, and grounded at the other end. A third capacitor 30 is electrically connected at one end in parallel with the second

resistor 31, and grounded at the other end.

A third resistor 33 is electrically connected to a node between the second detection diode 22 and the second buffer amplifier 20, and grounded at the other end. A fourth capacitor 32 is electrically connected at one end in parallel with the third resistor 33, and grounded at the other end.

A fourth resistor 28 is electrically connected in series between the first buffer amplifier 19 and the positive terminal of the adding amplifier 18. A fifth resistor 29 is electrically connected in series between the second buffer amplifier 20 and the positive terminal of the adding amplifier 18.

The adding amplifier 18 is grounded at the negative terminal through a sixth resistor 27.

A seventh resistor 26 is electrically connected between the negative terminal and an output port of the adding amplifier 18.

A portion encircled with a broken line defines an auto power control (APC) circuit 6.

Hereinbelow is explained an operation of the RF detection circuit in accordance with the first embodiment.

The RF signals are first modulated in the quadrature modulator 5, filtered in the interstage filter 16, and then, amplified in the power amplifier 4.

First, the RF signal having been amplified by the power amplifier 4 is received in the coupler 24. The RF signal is divided into two portions by the hybrid distributor 23. Each of the two portions is introduced into each of the first and second detection diodes 21 and 22.

Output voltages are transmitted from the first and second detection diodes 21 and 22 to the adding amplifier 18 through the first and second buffers 19 and 20, and are added to each other in the adding amplifier 18.

Then, the adding amplifier 18 transmits an output signal to the comparison circuit 17.

The comparison circuit 17 received the output signal transmitted from

the adding amplifier 18 and a control signal transmitted from a controller (not illustrated), compares these signals to each other, and transmits a signal indicative of the result of comparison, to the quadrature modulator 5, as a feed-back signal FS.

Hereinbelow are explained detection characteristics of the first and second detection diodes 21 and 22.

Fig. 4 illustrates each of the detection characteristics of the first and second detection diodes 21 and 22.

As illustrated in Fig. 4, the first detection diode 21 has such a characteristic as indicated with the curve A. Specifically, the first detection diode 21 can detect a voltage in the range of about 0.3V to 2.0V when the signal power is in the range of about −30 dBm to about 5 dBm. The second detection diode 22 has such a characteristic as indicated with the curve B. Specifically, the second detection diode 22 can detect a voltage in the range of about 0.3V to 2.0V when the signal power is in the range of about −5 dBm to about 30 dBm.

Fig. 5 illustrates detection characteristic obtained by combing the detection characteristics of the first and second detection diodes 21 and 22.

By combining the detection characteristics of the first and second detection diodes 21 and 22, there is obtained a detection characteristic as indicated in Fig. 5 with the curve (A+B). Specifically, a combination of the first and second detection diodes 21 and 22 electrically connected in parallel to each other can detect a voltage in the range of about 0.3V to 4.0V when the signal power is in the range of about −30 dBm to about 30 dBm.

Accordingly, the first embodiment makes it possible to provide detection characteristic in a wider range than that of the conventional RF detection circuit including a single detection diode.

Fig. 3 is a block diagram of an example of a RF circuit including the RF detection circuit in accordance with the first embodiment, illustrated in Fig. 2. The RF circuit is employed, for instance, in a mobile communicator such as a

cellular phone.

The illustrated RF circuit is comprised of a first antenna 1, a second antenna 2, an antenna switch 3 electrically connected to the first antenna 1, and switching the first antenna 1 between a receiver and a transmitter, a controller 8 transmitting a control signal to a later mentioned auto power control circuit 6, a modem or a modulator and demodulator 7 controlled by the controller 8 and transmitting IF signals to a later mentioned quadrature modulator 5, a power amplifier 4 receiving an output signal from the quadrature modulator 5, and amplifying the output signal, an auto power control (APC) circuit 6 as defined in Fig. 2 with a broken line, a synthesizer 9 transmitting I, Q signal to both the quadrature modulator 5 and later mentioned first and second mixers 12 and 13, a first RF amplifier 10 receiving a signal having been received through the first antenna 1, from the antenna switch 3, a second RF amplifier 11 receiving a signal having been received through the second antenna 2, a first mixer 12 receiving I, Q signal from the synthesizer 9 and an output signal from the first RF amplifier 10, and transmitting an output signal to a later mentioned first IF amplifier 14, a second mixer 13 receiving I, Q signal from the synthesizer 9 and an output signal from the second RF amplifier 11, and transmitting an output signal to a later mentioned second IF amplifier 15, a first IF amplifier 14 receiving an output signal from the first mixer 12, amplifying the output signal, and transmitting the amplified signal to the modem 7, and a second IF amplifier 15 receiving an output signal from the second mixer 13, amplifying the output signal, and transmitting the amplified signal to the modem 7.

In the RF circuit illustrated in Fig. 3, the first antenna 1 and the second antenna 2 cooperate with each other to accomplish antenna diversity.

In operation, the controller 8 transmits a control signal CS to the comparison circuit 17 in the auto power control circuit 6. Then, the RF detection circuit defined by the quadrature modulator 5, the power amplifier 4 and the auto power control circuit 6 operates in such a manner as having been explained with

reference to Fig. 2. As a result, the comparison circuit 17 transmits the feedback signal FS to the quadrature modulator 5.

[Second Embodiment]

Fig. 6 is a circuit diagram of a RF detection circuit in accordance with the second embodiment.

As illustrated in Fig. 6, the RF detection circuit is comprised of a quadrature modulator 5 receiving IF signal and IQ signal, modulating those signals, and transmitting a single output signal, an interstage filter 16 receiving the output signal from the quadrature modulator 5, filtering the output signal, and transmitting the filtered signal, a power amplifier 4 receiving the filtered signal from the interstage filter 16, amplifying the signal and transmitting an output signal, a directional coupler 24 receiving the output signal from the power amplifier 4 and branching the received output signal into two first signals, a variable attenuator 25 receiving one of the first signals from the directional coupler 24, attenuating the received first signal, and transmitting the attenuated first signal, a distributor 23 receiving the first signal from the variable attenuator 25, and dividing the received first signal into two second signals, a first detection diode 21 receiving one of the second signals from the distributor 23, detecting the received second signal, and transmitting a first output signal, a first buffer amplifier 19 receiving the first output signal from the first detection diode 21, amplifying the received first output signal, and transmitting a signal, a second detection diode 22 receiving one of the second signals from the distributor 23, detecting the received second signal, and transmitting a second output signal, a second buffer amplifier 20 receiving the second output signal from the second detection diode 22, amplifying the received second output signal, and transmitting a signal, an adding amplifier 18 receiving the signals at a positive terminal from the first and second buffer amplifiers 19 and 20, and grounded at a negative terminal, and a comparison circuit 17 receiving both an output signal transmitted from the adding amplifier 18 and a control signal transmitted from a controller

(not illustrated), comparing those signals to each other, and transmitting a signal indicative of comparison, to the quadrature modulator 5, as a feed-back signal.

A first resistor 38 is electrically connected at one end to the directional coupler 24 and grounded at the other end.

A first capacitor 36 is electrically connected in series between the directional coupler 24 and the first detection diode 21. A second capacitor 37 is electrically connected in series between the directional coupler 24 and the second detection diode 22.

A first choke coil 34 is electrically connected at one end to a node between the first capacitor 36 and the first detection diode 21, and electrically connected at the other end to a voltage source V_B. A second choke coil 35 is electrically connected at one end to a node between the second capacitor 37 and the second detection diode 22, and electrically connected at the other end to a voltage source V_B.

A second resistor 31 is electrically connected to a node between the first detection diode 21 and the first buffer amplifier 19, and grounded at the other end. A third capacitor 30 is electrically connected at one end in parallel with the second resistor 31, and grounded at the other end.

A third resistor 33 is electrically connected to a node between the second detection diode 22 and the second buffer amplifier 20, and grounded at the other end. A fourth capacitor 32 is electrically connected at one end in parallel with the third resistor 33, and grounded at the other end.

A fourth resistor 28 is electrically connected in series between the first buffer amplifier 19 and the positive terminal of the adding amplifier 18. A fifth resistor 29 is electrically connected in series between the second buffer amplifier 20 and the positive terminal of the adding amplifier 18.

The adding amplifier 18 is grounded at the negative terminal through a sixth resistor 27.

A seventh resistor 26 is electrically connected between the negative

terminal and an output port of the adding amplifier 18.

A portion encircled with a broken line defines an auto power control (APC) circuit 6.

In comparison with the first embodiment illustrated in Fig. 2, the RF detection circuit in accordance with the second embodiment is additionally comprised of the variable attenuator 25.

The variable attenuator 25 is operated as follows.

For instance, if a RF signal has a level equal to or greater than a first predetermined level, the variable attenuator 25 is kept on. Since the RF signal has a great level, even if the RF signal level is attenuated by the variable attenuator 25, the first and second diodes 21 and 22 can sufficiently detect the RF signal.

If the RF signal has a level equal to or lower than a second predetermined level, the variable attenuator 25 is turned off to thereby allow the RF signal to pass therethrough.

As mentioned earlier, in accordance with the second embodiment, since detection capability of the first and second diodes 21 and 22 can be effectively utilized by controlling a level of a RF signal, it is possible to detect RF signal power in a higher dynamic range.

It is not always necessary to frequently operate the variable attenuator 25 to widen a dynamic range, because the RF signal power tends to be discontinued while the variable attenuator 25 is in control. It is preferable that detection characteristic is first improved by operating the two detection diodes 21 and 22 in parallel like the first embodiment, and is further improved by the attenuator control, if necessary.

The RF circuit illustrated in Fig. 3 may be designed to include the RF detection circuit in accordance with the second embodiment, illustrated in Fig. 6, in place of the RF detection circuit in accordance with the first embodiment, illustrated in Fig. 2.

The RF detection circuits in accordance with the first and second embodiments are designed to include two detection diodes, that is, the first and second detection diodes 21 and 22. However, it should be noted that the number of detection diodes in the RF detection circuit is not to be limited to two. The RF detection circuit may be designed to include three or more detection diodes electrically connected in parallel with one another.

CLAIMS:

1. A radio frequency detection circuit comprising at least two diodes electrically connected in parallel with one another, said diodes having different ranges of a voltage which said diodes can detect.

2. The radio frequency detection circuit as set forth in claim 1, further comprising a attenuator through which a signal is transmitted to said diodes, said attenuator being turned on or off in accordance with a control signal.

3. The radio frequency detection circuit as set forth in claim 2, wherein said attenuator is turned on when a transmitted signal has a level equal to or greater than a first threshold level, and is turned off when a transmitted signal has a level equal to or smaller than a second threshold level.

4. The radio frequency detection circuit as set forth in claim 2 or 3, wherein said attenuator is a variable attenuator.

5. The radio frequency detection circuit as set forth in any one of claims 1 to 4, wherein said radio frequency detection circuit includes two diodes.

6. A radio frequency detection circuit comprising:

(a) a modulator receiving first and second signals, and transmitting an output signal;

(b) a directional coupler receiving said output signal from said modulator, and dividing the thus received output signal into two first signals;

(c) a distributor receiving one of said two first signals from said directional coupler, and dividing the thus received first signal into two second signals:

(d) a first diode receiving one of said two second signals from said distributor,

and transmitting a first output signal;

(e) a second diode receiving the other of said two second signals from said distributor, and transmitting a second output signal;

(f) an adder adding said first and second output signals to each other, and transmitting a sum signal; and

(g) a comparison circuit receiving said sum signal and a control signal, comparing said sum signal to said control signal, and transmitting a feed-back signal indicative of comparison, to said modulator.

7. The radio frequency detection circuit as set forth in claim 6, further comprising a attenuator electrically connected in series between said directional coupler and said distributor, said attenuator receiving said control signal in accordance with which said attenuator is turned on or off.

8. The radio frequency detection circuit as set forth in claim 7, wherein said attenuator is turned on when said control signal has a level equal to or greater than a first threshold level, and is turned off when said control signal has a level equal to or smaller than a second threshold level.

9. The radio frequency detection circuit as set forth in claim 7, wherein said attenuator is a variable attenuator.

10. The radio frequency detection circuit as set forth in any one of claims 6 to 9, further comprising:

(h) a first buffer amplifier electrically connected in series between said first diode and said adder; and

(i) a second buffer amplifier electrically connected in series between said second diode and said adder.

11. The radio frequency detection circuit as set forth in any one of claims 6 to 9, further comprising:

(j) a first capacitor electrically connected in series between said distributor and said first diode; and

(k) a second capacitor electrically connected in series between said distributor and said second diode.

12. A radio frequency detection circuit comprising:

(a) a modulator receiving first and second signals, and transmitting an output signal;

(b) a directional coupler receiving said output signal from said modulator, and dividing the thus received output signal into two first signals;

(c) a distributor receiving one of said two first signals from said directional coupler, and dividing the thus received first signal into N second signals wherein N is an integer equal to or greater than 3;

(d) first to N-th diodes each receiving one of said N second signals from said distributor, and transmitting a first to N-th output signal;

(e) an adder adding said first to N-th output signals to one another, and transmitting a sum signal; and

(g) a comparison circuit receiving said sum signal and a control signal, comparing said sum signal to said control signal, and transmitting a feed-back signal indicative of comparison, to said modulator.

13. The radio frequency detection circuit as set forth in claim 12, further comprising a attenuator electrically connected in series between said directional coupler and said distributor, said attenuator receiving said control signal in accordance with which said attenuator is turned on or off.

14. The radio frequency detection circuit as set forth in claim 13, wherein

said attenuator is turned on when said control signal has a level equal to or greater than a first threshold level, and is turned off when said control signal has a level equal to or smaller than a second threshold level.

15. The radio frequency detection circuit as set forth in claim 13, wherein said attenuator is a variable attenuator.

16. The radio frequency detection circuit as set forth in any one of claims 12 to 15, further comprising first to N-th buffer amplifiers each electrically connected in series between said first to N-th diodes and said adder

17. The radio frequency detection circuit as set forth in any one of claims 12 to 15, further comprising first to N-th capacitors each electrically connected in series between said distributor and said first to N-th diodes.

18. A method of detecting radio frequency, comprising the steps of:

(a) modulating first and second signals, and transmitting an output signal;

(b) dividing said output signal into two first signals;

(c) detecting said two first signals, and resultingly transmitting two second signals;

(d) adding said two second signals to each other, and transmitting a sum signal; and

(e) comparing said sum signal to a control signal, and transmitting a feed-back signal indicative of comparison, said feed-back signal being fed back to said step (a).

19. The method as set forth in claim 18, further comprising the step of (f) attenuating said output signal, said step (f) being to be carried out after said step (a), but prior to said step (b).

20. A method of detecting radio frequency, comprising the steps of:

(a) modulating first and second signals, and transmitting an output signal;

(b) dividing said output signal into N first signals wherein N is an integer equal to or greater than 3;

(c) detecting said N first signals, and resultingly transmitting N second signals;

(d) adding said N second signals to one another, and transmitting a sum signal; and

(e) comparing said sum signal to a control signal, and transmitting a feed-back signal indicative of comparison, said feed-back signal being fed back to said step (a).

21. The method as set forth in claim 20, further comprising the step of (f) attenuating said output signal, said step (f) being to be carried out after said step (a), but prior to said step (b).

22. A radio frequency circuit to be used in a mobile transceiver, comprising:

(a) a controller transmitting a control signal;

(b) a modem transmitting first and second signals;

(c) a modulator receiving said first and second signals, and transmitting an output signal;

(d) a directional coupler receiving said output signal from said modulator, and dividing the thus received output signal into two first signals;

(e) a distributor receiving one of said two first signals from said directional coupler, and dividing the thus received first signal into two second signals;

(f) a first diode receiving one of said two second signals from said distributor, and transmitting a first output signal;

(g) a second diode receiving the other of said two second signals from said

distributor, and transmitting a second output signal;

(h) an adder adding said first and second output signals to each other, and transmitting a sum signal; and

(i) a comparison circuit receiving said sum signal and said control signal, comparing said sum signal to said control signal, and transmitting a feed-back signal indicative of comparison, to said modulator.

23. The radio frequency circuit as set forth in claim 22, further comprising a attenuator electrically connected in series between said directional coupler and said distributor, said attenuator receiving said control signal in accordance with which said attenuator is turned on or off.

24. The radio frequency circuit as set forth in claim 23, wherein said attenuator is turned on when said control signal has a level equal to or greater than a first threshold level, and is turned off when said control signal has a level equal to or smaller than a second threshold level.

25. The radio frequency detection circuit as set forth in claim 22 or 23, wherein said attenuator is a variable attenuator.

26. A radio frequency circuit to be used in a mobile transceiver, comprising:

(a) a controller transmitting a control signal;

(b) a modem transmitting first and second signals;

(c) a modulator receiving said first and second signals, and transmitting an output signal;

(d) a directional coupler receiving said output signal from said modulator, and dividing the thus received output signal into two first signals;

(e) a distributor receiving one of said two first signals from said directional coupler, and dividing the thus received first signal into N second signals wherein

N is an integer equal to or greater than 3;

(f) first to N-th diodes each receiving one of said N second signals from said distributor, and transmitting a first to N-th output signal;

(g) an adder adding said first to N-th output signals to one another, and transmitting a sum signal; and

(h) a comparison circuit receiving said sum signal and said control signal, comparing said sum signal to said control signal, and transmitting a feed-back signal indicative of comparison, to said modulator.

27. The radio frequency circuit as set forth in claim 26, further comprising a attenuator electrically connected in series between said directional coupler and said distributor, said attenuator receiving said control signal in accordance with which said attenuator is turned on or off.

28. The radio frequency circuit as set forth in claim 27, wherein said attenuator is turned on when said control signal has a level equal to or greater than a first threshold level, and is turned off when said control signal has a level equal to or smaller than a second threshold level.

29. The radio frequency detection circuit as set forth in claim 27 or 28, wherein said attenuator is a variable attenuator.

30. A radio frequency detection circuit substantially as described herein with reference to Figures 2 to 6 of the accompanying drawings.

31. A method of detecting radio frequency substantially as described herein with reference to Figures 2 to 6 of the accompanying drawings.

32. A radio frequency circuit substantially as described herein with reference

to Figures 2 to 6 of the accompanying drawings.

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25.

Application No: GB 0013867.7
Claims searched: 1 to 5

Examiner: John Donaldson
Date of search: 30 June 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H3R(RADD)

Int Cl (Ed.7): H03D 1/00, 1/02, 1/08, 1/10

Other: Online:WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2211042 A (MICROPHASE), see abstract	-

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